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RIPARIAN FIRE HISTORY AND FIRE REGIMES

UPPER SWAN VALLEY, FLATHEAD NATIONAL FOREST

1998 Upper Swan Valley Fire History Assessment #1



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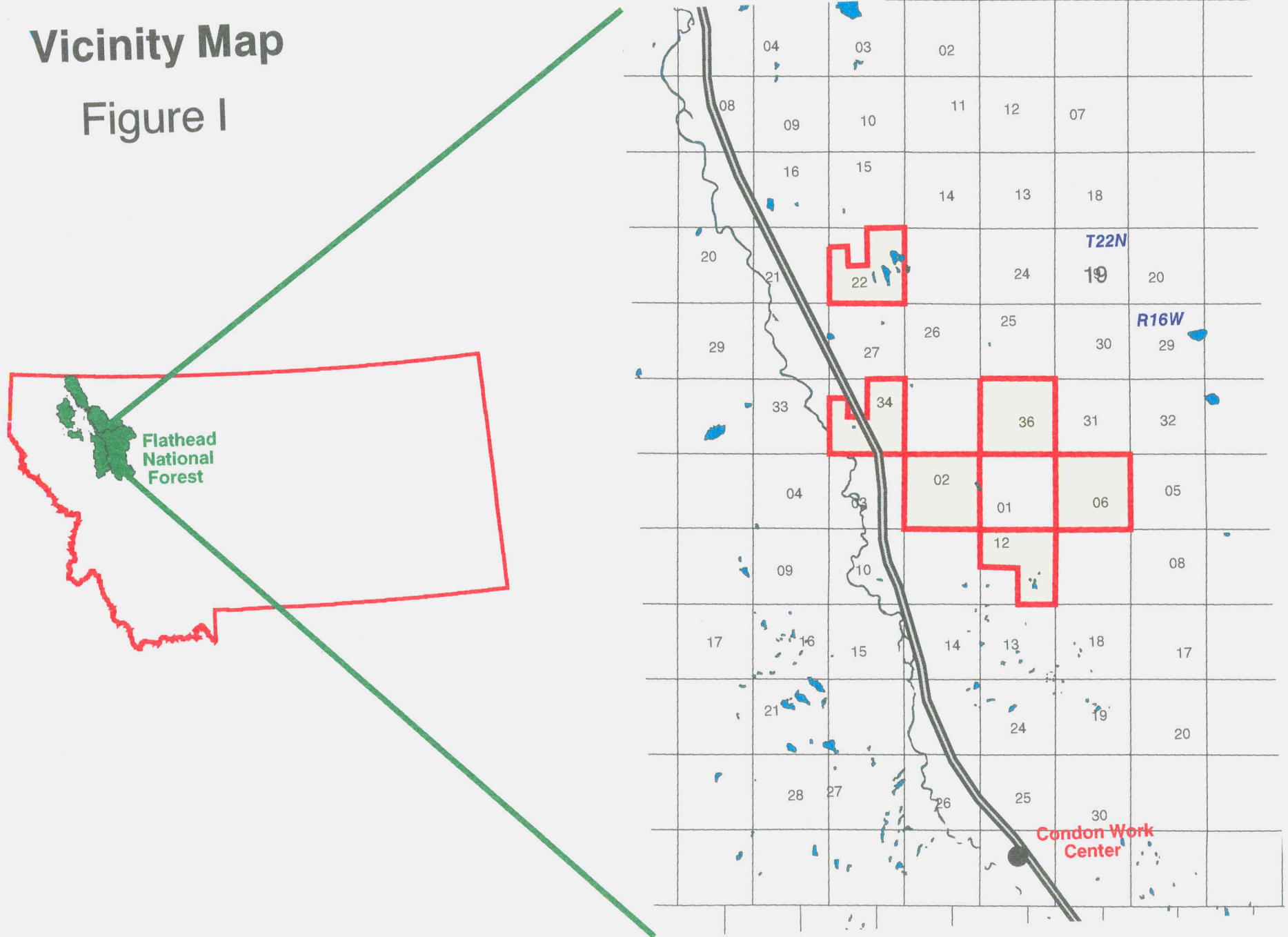
INTRODUCTION

During the spring of 1998, a riparian fire history assessment was conducted in the Upper Swan Valley, Flathead National Forest. The goal was to determine riparian fire regimes and area fire history to help managers design possible management strategies for the upper Swan Valley. Specific objectives were to: 1) sample presettlement fire history, 2) model presettlement fire regimes, and 3) document the effects of attempted fire exclusion after 1900. Previous studies (Freedman and Habeck 1985, Arno et al. 1995) had interpreted fire history in relatively dry valley bottom stands, but not for adjacent riparian zones.

The study area (3400-4200 ft. elev.) occurs within a 6000-acre area of “checkerboard” ownership near Condon, Montana (fig. 1). Of the 3600-acre federally owned portion, riparian landtypes occupy about 680 acres including wet meadows. Gently sloping moraines in the valley bottom surround numerous glacial potholes, some of which are occupied by the globally rare and threatened water howellia (*Howellia aquatilis*). In general, few fire history data have been obtained for riparian zones in the Northern Rockies (Agee 1993, Quigley et al. 1996), and are especially lacking for glacial pothole environments. Consequently, riparian stands bordering howellia sites were an important focus of the fire history sampling. Additional sampling was conducted in alluvial (streamside) riparian stands, both in the valley bottom and along the eastern edge of the study area, which trends toward mountain canyon topography.

The composition and structure of the area’s riparian stands varies by terrain type. Stands on well drained benches surrounding potholes support various mixes of relatively open-grown ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and

Vicinity Map Figure I



Douglas-fir (*Pseudotsuga menziesii*) (e.g., cool-moist spruce [*Picea* spp.] and warm-dry Douglas-fir habitat types [Pfister et al. 1977]). By contrast, alluvial stands on wetter soils are more heavily stocked, and are dominated by various mixes of western larch, Douglas-fir, lodgepole pine, spruce, and grand fir (*Abies grandis*)(e.g., warm-moist grand fir h.t.s).

METHODS

The methods of Arno and Sneek (1977) and Barrett and Arno (1988) were used to sample fire history. Specifically, partial cross-sections were sawn from fire scarred trees, and an increment borer was used to sample fire-regenerated age classes along transects in the study area. At each sample site, forest cover type and habitat type were documented in 375 m² circular plots. Successional trends were documented in the plots by estimating the canopy coverages of each tree species by four d.b.h. classes: 1) seedlings/saplings [0-4 in.], 2) poles [4-12 in.], 3) mature trees [12-30 in.], and 4) old growth trees [30+ in.].

The fire scar- and increment core samples were air-dried and sanded, then analyzed with a 10-20x binocular microscope. Fire year estimates were compiled into stand- and study area master fire chronologies (Romme 1980, Arno and Peterson 1983), as follows. Closely similar scar year estimates were adjusted to those obtained from nearby samples yielding the clearest ring counts. Then stand fire chronologies were produced by listing the estimated fire years and fire intervals for each site (Arno and Peterson 1983). Stand structure was determined by examining the piths of sample trees relative to the stand fire years, to assess whether the stands were even- or uneven aged. Subsequently, the fire year data were organized into a master fire chronology (Romme 1980) for the entire study area, enabling an

analysis of coarse-scale fire frequency.

Fire frequency was analyzed for each sample stand, and for the entire study area, as follows. The fire year data were used to calculate: 1) mean fire interval [MFI], 2) fire interval range, and 3) number of years since the last fire. For planning purposes, the first two pieces of data above document the natural range of variability in presettlement fire frequency, for both the stand- and landscape scales. Conversely, the effectiveness of attempted fire exclusion is measured by the years-since-last-fire data.

RESULTS AND DISCUSSION

Area Fire Patterns. Sampling at 20 sites produced 43 fire scar cross sections and increment cores from fire-regenerated seral classes (fig. 1). In addition to yielding data for riparian stands, the plots from this and earlier studies (Freedman and Habeck 1985, Arno et al. 1995) were sufficiently well distributed to allow estimation of fire frequency for the entire 6000-acre study area near Condon. Results indicate a very robust fire history. The earliest fire evidence dated from about 1489 A.D.. However, the relatively continuous portion of the database spans 397 years, between circa 1600 to 1997 (Appendix). The master fire chronology, including four fire years from previous studies (Freedman and Habeck 1985, Arno et al. 1995) contains an estimated 41 fire years between 1600 and 1919 — which was the last fire of any consequence in the study area. Fires occurred in nearly every calendar decade between 1600 and 1919 (fig. 2), and the area MFI was just eight years (fig. 3). That is, on average, a fire occurred somewhere in the 6000-acre area at least every eight years between 1600 and 1919. Intervals between fires in the chronology ranged from three to 18 years long. Also note that these estimates likely are conservative. First, sampling did not occur on the five privately

Fig. 2. Master Fire Chronology
1600-1997 A.D.

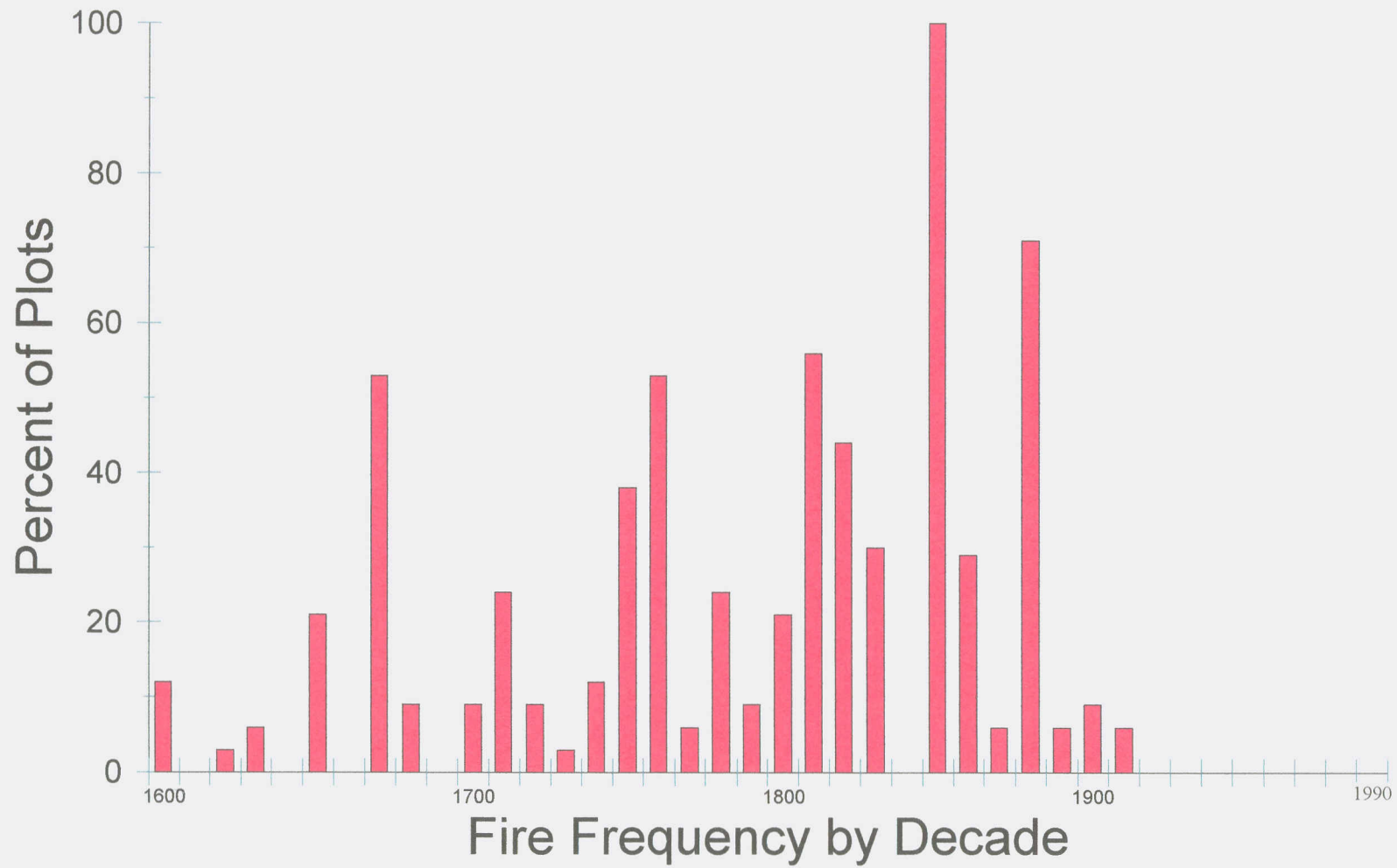
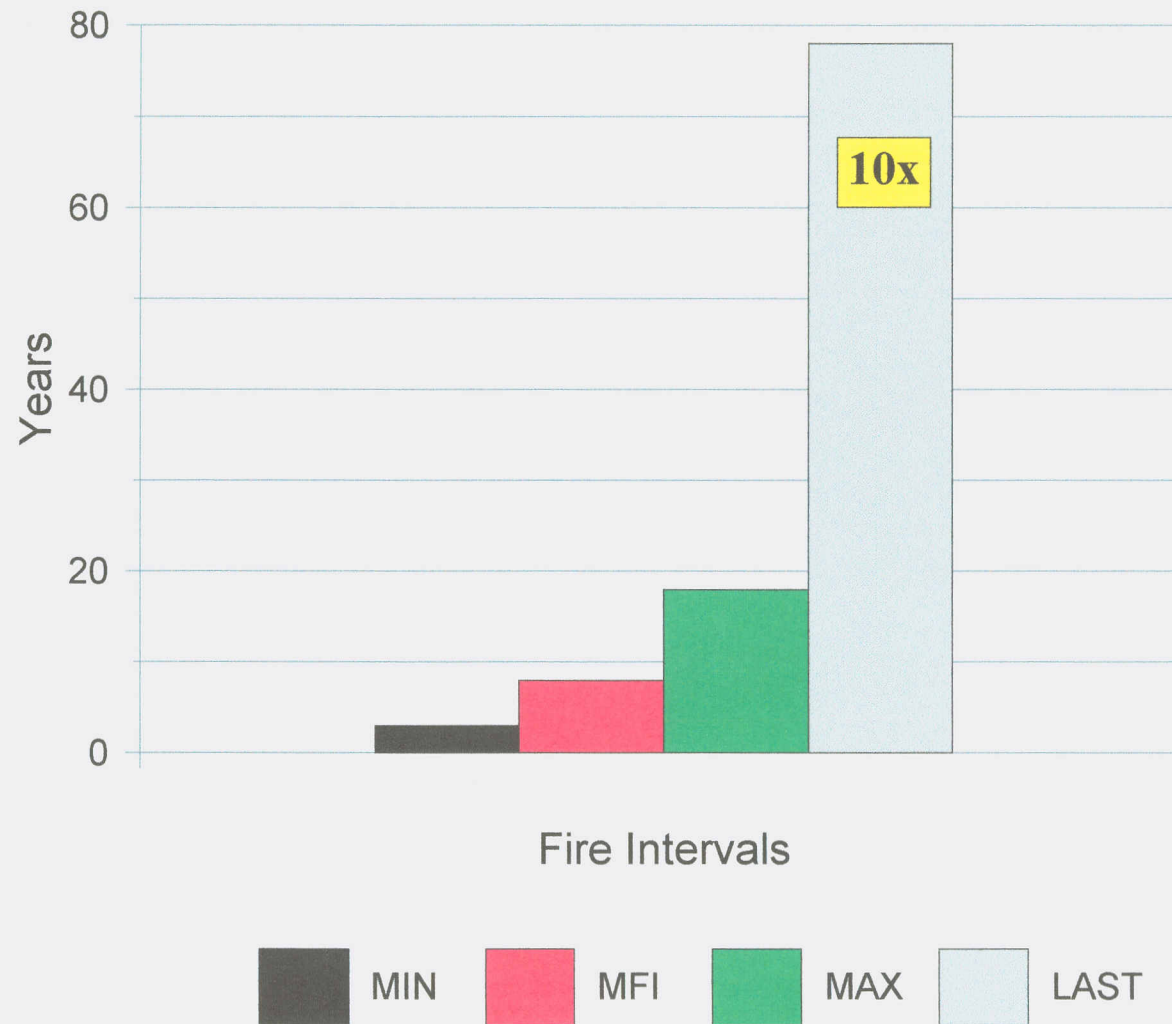


Fig. 3. Historic Fire Intervals vs.
Years Since Last Fire.



owned sections within the 6000-acre perimeter. Similarly, sampling may not have detected every small fire because scar evidence inevitably diminishes over time (Arno 1976, Barrett and Arno 1982). The fire atlas (on file, FNF) verifies that eight decades have passed since the last wildfire, in 1919. The current fire interval is therefore at least 10 times longer than the presettlement MFI. Also note that more than a century has passed since the last major fire (i.e., 1889).

High presettlement fire frequency and advancing forest succession during this century have largely obscured old burn margins in the valley bottom. But, based on the plot locations, presettlement fires were often limited in extent, or, were light underburns that failed to scar many trees. Nearly 80 percent of all fires in the chronology were recorded in 10 percent or fewer of the 34 plots sampled by all three studies (Freedman and Habeck 1985, Arno et al. 1995). Major fires, defined here as occurring in at least 30 percent of the plots, occurred eight times and averaged every 46 years during the 3-century span of continuous data. (Note that the term “major fire” relates only to the size of the 6000-acre study area, which is smaller than many wildfires). The last major fire occurred in 1889, and was recorded by 68 percent of the plots. In fact, 1889 was the most severe drought year in the Columbia Basin between about 1670 and 1970 (Graumlich 1987), and likely was the most extensive fire year in that region between 1500 A.D. and the present (Barrett et al. 1997). Other important fire years in the upper Swan Valley occurred in 1850 (68% of the plots), 1814 (47%), and in 1768 (53%). Currently, the study area has not experienced a major fire in 109 years — versus the 46-year average interval between 1600 and 1919.

The relatively uniform fire frequency throughout dry- and wet climatic periods (Karl and Koscielny 1982, Graumlich 1987, Meko et al. 1993, Barrett et al. 1997) strongly suggests that Indian

ignitions had supplemented the area's already frequent lightning fires (Barrett and Arno 1982, Gruell 1985). In fact, one descendant of Swan Valley settlers said his parents commonly observed Indians setting fires every fall, upon departing for the winter encampments (pers. comm. with FNF Archaeologist G. Maclean, 7/89). (Coincidentally, an informant gave me virtually the same information regarding Indian burning in the Ninemile Valley northwest of Missoula [Barrett 1981]). Early forest surveyor H. B. Ayres likewise mentioned that Indians and settlers had caused fires in the Swan Valley during the mid- to late 1800s (Ayres 1900).





The fire atlas map (on file, FNF) also shows unusually frequent ignitions from both lightning and humans since 1930 (pers comm. with For. Tech. J. Ingebretson, Swan Lake R.D.). Post-1900 records are incomplete, but at least 100 ignitions have occurred in and near the study area in recent decades (fig. 4). It is not known whether the area receives more lightning strikes than other portions of the Seeley-Swan Valley, or whether the area's drier stands are simply more prone to ignition. However, the atlas shows that virtually all fires during this century have been suppressed at less than one-quarter acre in size. Based on the presettlement fire frequency, as many as 10 or 15 spreading fires might have occurred without fire suppression.

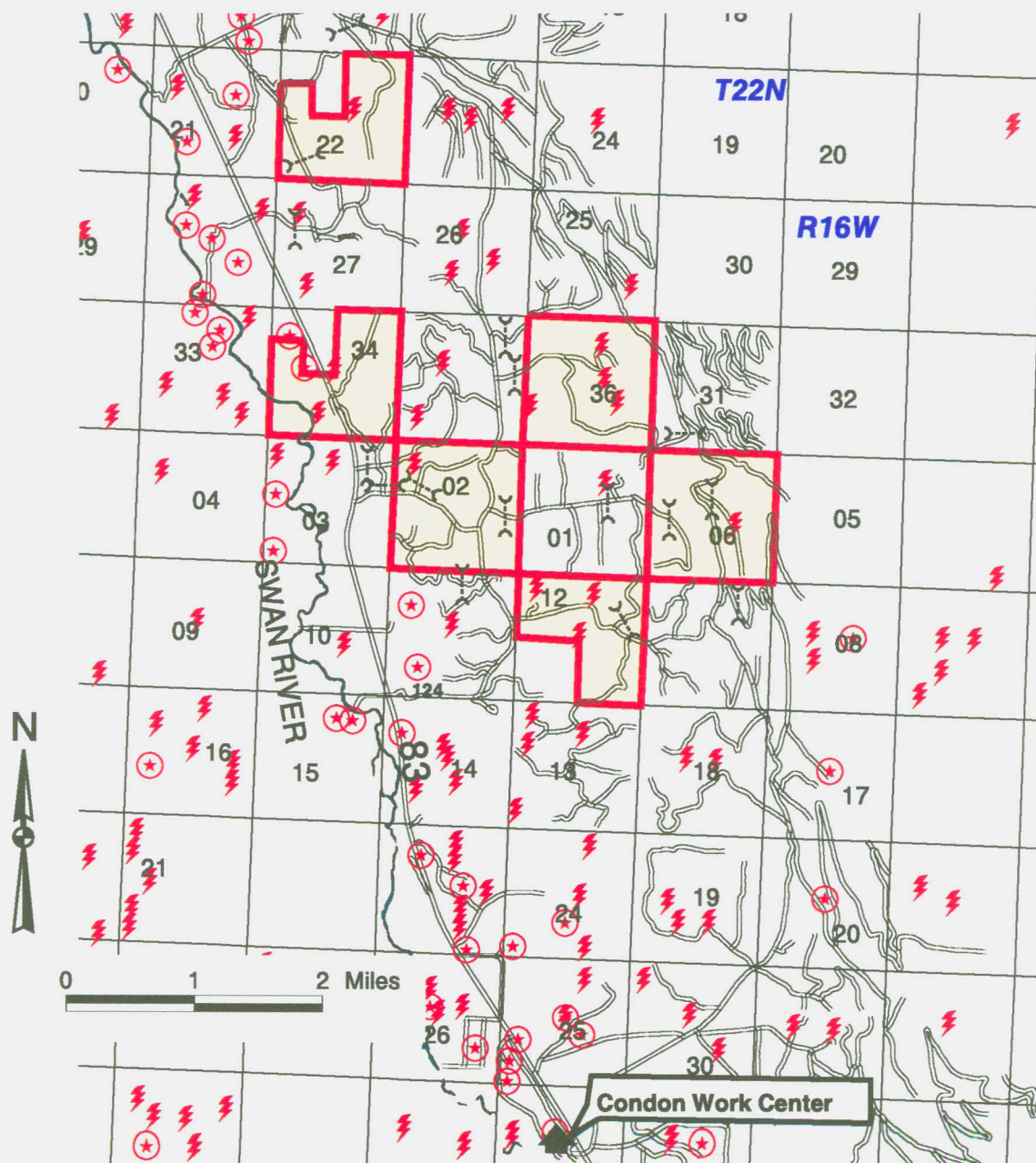
Stand Fire Patterns. In addition to interpreting area fire history, fire patterns were analyzed at the stand scale. Data for riparian stands are presented below according to different site types: 1) lacustrine (pothole) sites, including water howellia habitat, and 2) alluvial (streamside) sites in the valley bottom and adjacent to mountain canyons.

Fire scarred trees range from common to scarce on any given site, but most stands contain multiple fire-regenerated age classes. This pattern suggests that nonlethal- and mixed severity fires,

Fig.4 Fire Starts 1936-1997

Legend

-  Lightning
-  Man-Caused
-  Roads
-  Sections in Study Area



rather than stand replacing fires, were the predominant severity types (Barrett et al. 1991, Agee 1993, Quigley et al. 1996). However, two distinct mixed severity fire regimes were found in the study area. That is, different fire frequency- and severity patterns were found in moderately dry- versus moist site types (i.e., lacustrine vs. alluvial riparian stands).

Pothole Riparian Stands. Long-term data were obtained from 10 stands bordering glacial potholes (table 1, fig. 5). Fire scarred trees commonly are found in these stands, often just a few feet from shoreline. The data suggest frequent nonlethal and mixed severity fires, with site MFIs ranging from 14 to 27 years long before 1900 (10-stand mean: 21 yr). By contrast, the current fire intervals range from 78 to 147 years long. The 10-stand mean of 109 years since the last fire is five times longer than the overall presettlement MFI. The most striking example of effective fire exclusion comes from Site 6 in the lower Pony Creek drainage (table 1). The MFI was just 14 years between 1721 and 1850, but the stand has not burned during the last 147 years — an eleven-fold increase in interval length.

These presettlement MFIs are unusually short for such relatively moist habitat types (e.g., *Clintonia uniflora* and *Vaccinium caespitosum* associations). In fact, these fire frequencies are only one-third to one-half the length of those found for similar stands elsewhere in the Northern Rockies (Quigley et al. 1996). The low variation in fire intervals also suggests that the fire regimes were heavily influenced by Indians (Barrett and Arno 1982, Arno et al. 1997).

Previous studies on adjacent drier aspects (Freedman and Habeck 1985, Arno et al. 1995) found similar presettlement MFIs, ranging from 15 to 30 years long. A dry ponderosa pine site in the mid-Dog Creek drainage sampled during this study also yielded a site MFI of 20 years before 1900.

Table 1. Fire frequency- and site data from 10 plots in lacustrine (pothole) riparian stands, upper Swan Valley (*PP/WL/DF* and *WL/LPP/DF* cover types). Data indicate nonlethal and mixed severity fires (*MS I* regime).

Plot No. ¹	Site Type ²	Hab. Type ³	Asp.	Elev (ft)	MFC ⁴	No. Fires	Intvl. Range (yr)	MFI (yr) ⁵	Last Fire ⁶ (yr)
5	P	Psme/Vaca	E	3620	1670-1889	12	7-36	20	108
6	P	Picea/Clun	SW	3580	1721-1850	10	5-25	14	147
10	H	Psme/Vaca	S	3590	1609-1889	13	9-47	23	108
11	H	Picea/Clun	N/F	3580	1768-1899	6	3-64	26	98
12	H	Picea/Clun	F	3570	1653-1919	16	4-51	18	78
13	H	Psme/Vaca	W	3650	1633-1919	17	6-27	18	78
14	P	Psme/Vaca	SW	3640	1814-1889	5	10-27	19	108
16	P	Picea/Clun	F	3610	1817-1889	4	17-33	24	108
17	P	Psme/Vaca	F	3630	1700-1859	7	9-52	27	138
18	P	Abla/Clun	F	3635	1768-1889	8	5-34	17	108
					Range: 3580-3650	1609-1919	4-17	3-64	14-27
					Mean: 3611	-	10	8-40	21
									78-147

1. Locations on study area map (on file, FNF and Swan Ecosystem Center).

2. Site Type Code: **P**: lacustrine (pothole) site; **H**: *Howellia* pothole.

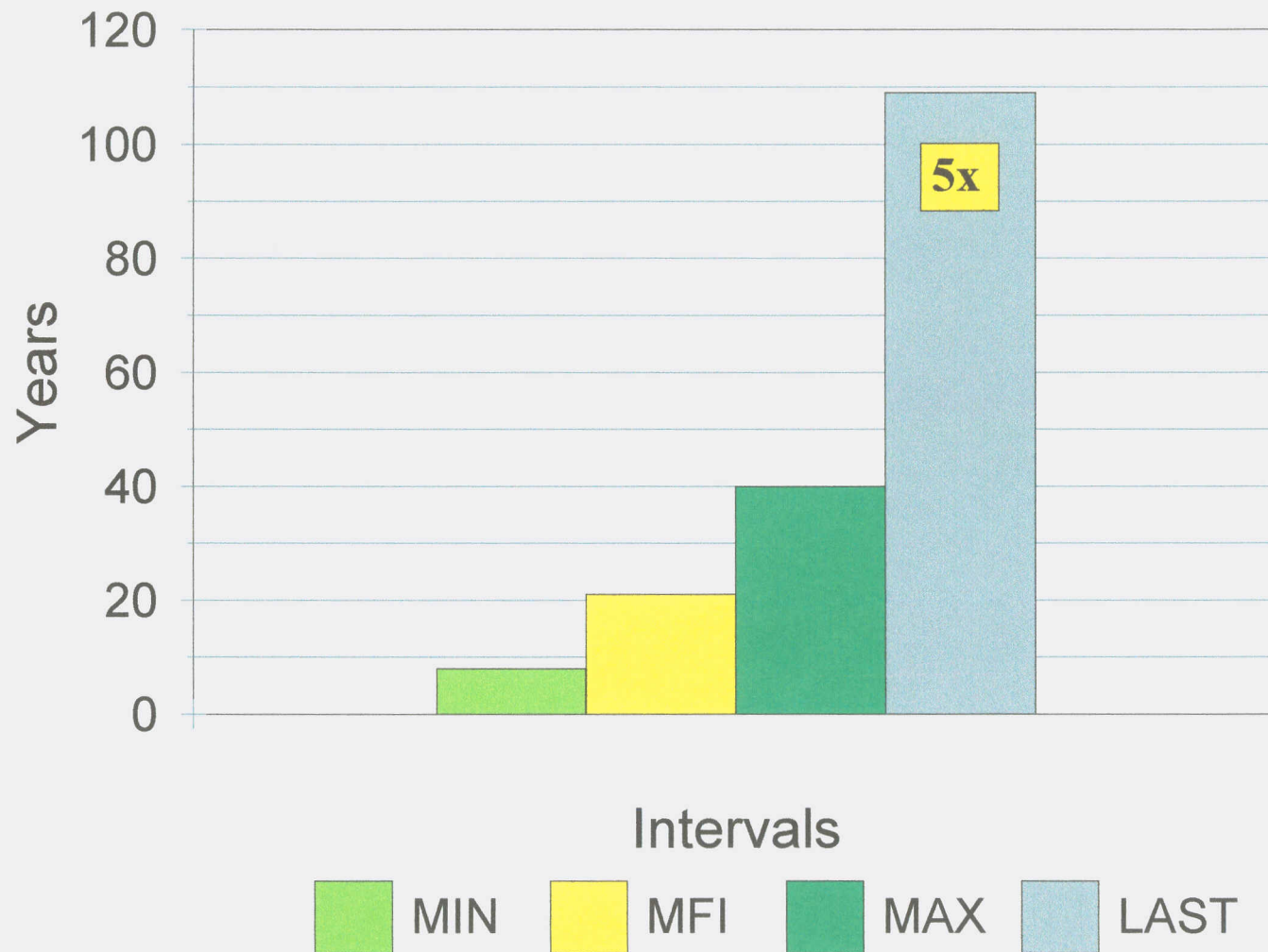
3. Habitat type acronymns follow Pfister et al. (1977).

4. Stand Master Fire Chronology.

5. Mean Fire Interval.

6. As of 1997.

Fig. 5. Avg. Fire Intervals: PP-WL-DF
Pothole sites (n=10 plots)

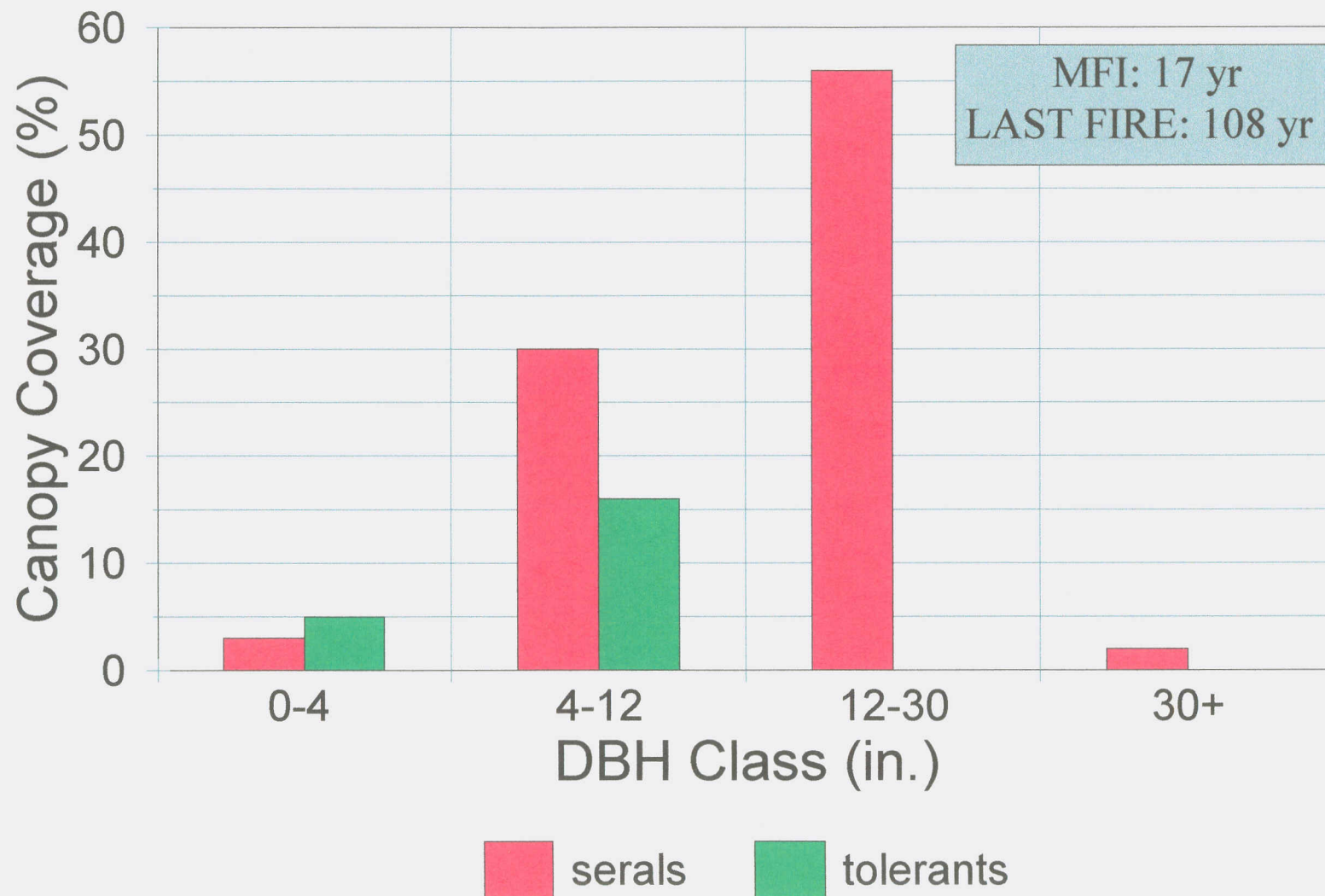


Freedman and Habeck (1985) had stated that their data were insufficient for interpreting whether nearby riparian sites had different presettlement fire regimes. However, the results from this sampling indicate that fire regimes in pothole riparian stands were virtually identical.

Most pothole stands do not fit the generally accepted definition of “riparian”, in that tree regeneration was often limited by inherently droughty soils and by competing understory vegetation such as pinegrass (Pfister et al. 1977). These relatively open grown stands (Freedman and Habeck 1985, Arno et al. 1995) promoted fuel drying, and hence frequent understory fires helped maintain long-term dominance by early serals such as ponderosa pine and western larch. Infilling of stand understories during the fire exclusion period has been well documented for the study area (Freedman and Habeck 1985, Arno et al. 1995). These researchers concluded that, in unlogged stands in the valley bottom, advancing succession has promoted a shift toward potential stand replacing fires. In some pothole-edge stands, the current overstocking is comprised largely of early seral trees, rather than shade tolerants (fig. 6). That is, numerous ponderosa pines that became established after the large 1889 fire have maintained dominance despite a subsequent lack of five or six thinning fires.

Fundamental questions exist about fire’s influence on water howellia habitat (Forum on Research and Management of *Howellia aquatilis*, 1998). For example, fires may have directly affected potholes by burning dried mats of competing vegetation during late summer. Fires also likely influenced hydrologic cycles, for example, by altering water chemistry and potential sedimentation. Pond fluctuations also may have been affected over the long-term, because frequent fires controlled stand density near shorelines. By contrast, lack of fire during this century has promoted fundamental changes in stand structure and composition adjacent to some howellia sites (Freedman and Habeck

Fig. 6. Successional Trends, PP-WL-DF
Pothole Stand 18



1985, Arno et al. 1995). Greatly increased tree densities presumably can alter pond hydrologic systems. For example, greater transpiration demands could lower area water tables. Repeat photography at Daphnia Pond near Bigfork (Gruell 1983) provides a possible example: a photograph taken in 1902 after a recent mixed severity fire shows substantially more open water than in 1981, by which time the area had been heavily invaded by cattails and dense conifers (fig. 7).

Long-term fire exclusion clearly has promoted a shift toward the stand replacement fire regime across a broad area in the upper Swan Valley (Freedman and Habeck 1985, Hart 1994, Arno et al. 1995). In terms of cumulative effects, unprecedented stand replacing fires would further promote the loss of old growth trees on the area's few remaining unlogged sites. Elsewhere in the Seeley-Swan Valley, water howellia has been found in potholes that were overrun by stand replacing fires in the early 1900s (pers. comm. with FNF Botanist M. Mantas, 5/98). Heavy tree regeneration has occurred since then, similar to regeneration patterns on sites that previously experienced nonlethal- and mixed severity fires. Other populations have been found in ponds adjacent to sites largely denuded by heavy logging and roading. Consequently, water howellia may occur under a wide range of disturbance regimes. Since information on the specie's historic range is lacking, whether fire exclusion has benefitted or harmed water howellia habitat remains unclear.

Alluvial Stands. Data were obtained from seven alluvial sites dominated by various mixes of conifers in the area's moderately warm and moist habitat types (e.g., larch-lodgepole-Douglas-fir stands in *ABGR/CLUN* h.t.)(table 2, fig. 8). These stands fit the generally accepted definition of riparian stands, because wetter and deeper soils promote dense tree stocking and more shade tolerant trees. However, repeated fires often allowed early serals such as western larch to



Plate 8a (1902) Fire Group 6: Moist Douglas-fir. Elevation 3,100 ft (945 m)

Camera faces north toward Daphnia Pond and Swan Range on the east side of Flathead Lake, 3 miles north of Woods Bay. Snags attest to a fire in the late 1800's that killed most of the coniferous forest around the pond. Removal of conifers stimulated heavy growth of herbs and shrubs.

Photograph by M. J. Elrod, courtesy University of Montana Archives and Special Collections.



Plate 8b (September 28, 1981) 79 years later

Fall haze obscures Swan Range in distance. Cattail growth now obscures pond surface. Dense conifers including ponderosa pine, Douglas-fir, larch, and spruce have regenerated on near slope at right. Cottonwood and dogwood flourish along pond edge, while shade-intolerant shrubs are on the decline beneath the conifer canopy.

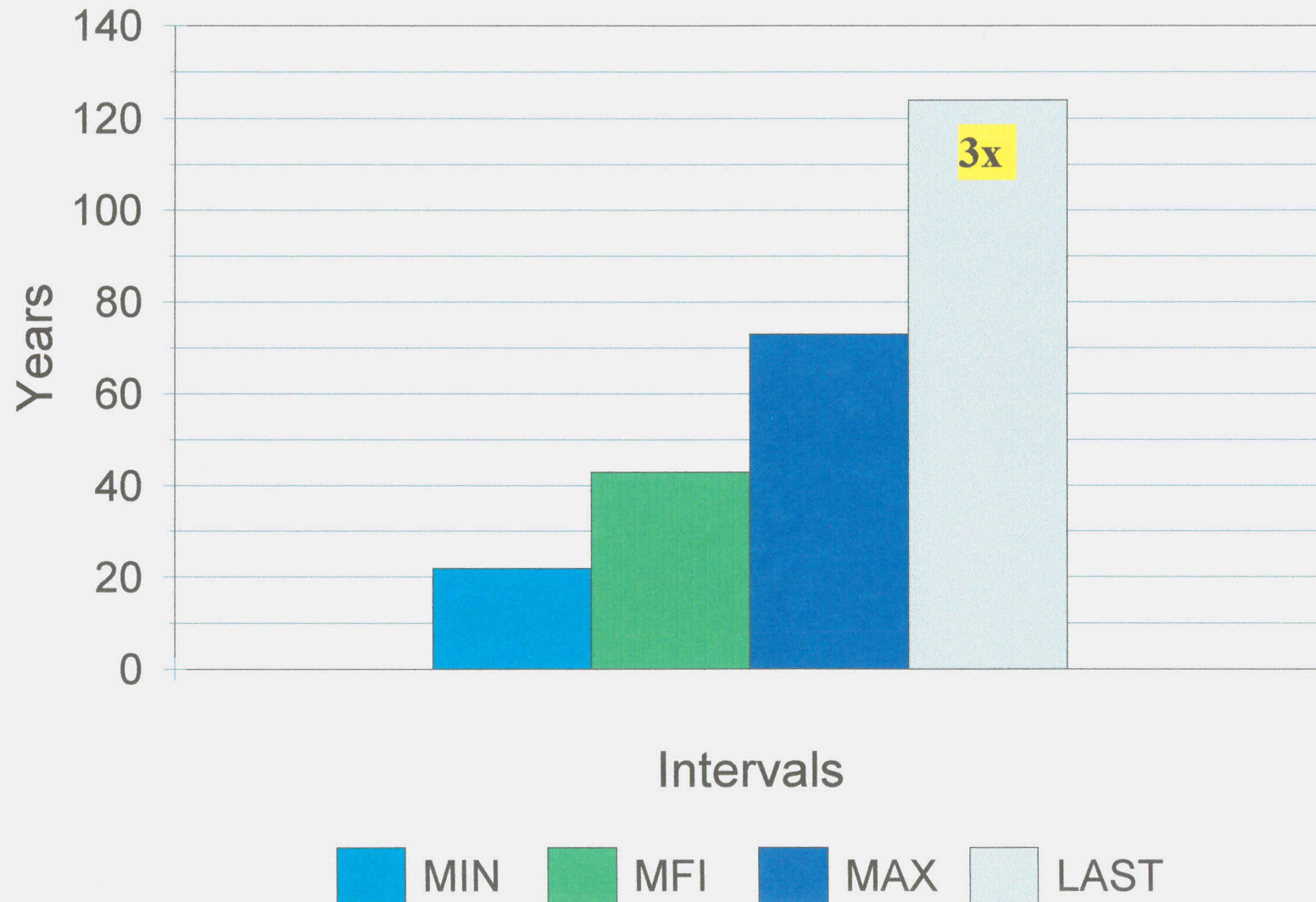
Photograph by G. E. Gruell.

Table 2. Fire frequency- and site data from 7 plots in alluvial (streamside) riparian stands, upper Swan Valley (*WL/LPP/DF* cover type). Data indicate primarily mixed severity fires (*MS II* regime).

Plot No. ¹	Site Type ²	Hab. Type ³	Asp.	Elev (ft)	MFC ⁴	No. Fires	Intvl. Range (yr)	MFI (yr) ⁵	Last Fire ⁶ (yr)	
1/2/9	C	Thpl/Clun	NW	4210	1670-1850	3	36-144	90	147	
3	C	Abgr/Clun	N	4230	1768-1853	4	19-46	28	144	
7	V	Picea/Clun	SW	3590	1677-1874	5	49-91	49	123	
8	V	Picea/Clun	N	3570	1768-1874	4	17-67	35	123	
15	V	Psme/Vaca	SE	3680	1835-1889	3	22-32	27	108	
19	V	Abgr/Clun	S	4050	1757-1889	6	10-39	26	108	
20	V	Abgr/Clun	W	3960	1768-1889	4	10-89	40	108	
Range:					3570-4230	1677-1889	3-6	10-144	26-90	108-147
Mean:					3899	-	4	22-73	43	124

1. Locations on study area map (on file, FNF and Swan Ecosystem Center).
2. Site Type Code: **C**: canyon-edge alluvial site; **V**: valley-bottom alluvial site.
3. Habitat type acronymns follow Pfister et al. (1977).
4. Stand Master Fire Chronology.
5. Mean Fire Interval.
6. As of 1997.

Fig. 8. Avg. Fire Intervals: WL-LP-DF
Alluvial Sites (n=7 plots)



dominate such sites.

Mixed severity fires were comparatively frequent in these stands before 1920, and burned at low- to moderate intensities that often produced multiple even-age classes (i.e., seral component). However, site MFIs were highly variable. Pre-1920 MFIs ranged from about 25 to 90 years long, whereas the sites' current fire intervals range from 108 to 147 years long. The 7-stand average MFI was 43 years, as opposed to the current fire interval of 124 years — a threefold increase over the average MFI. The sampling thus suggests that from one to five fires have been precluded from any given alluvial stand in the Swan Valley bottom. By comparison, a trend toward longer interval, stand replacing fires was observed along the valley's eastern edge, near the mountain canyons. For example, Stand One in the upper Dog Creek drainage yielded a site MFI of 90 years, and this *THPL/CLUN* habitat type typically is classified under the stand replacement regime (Quigley et al. 1996).

Old larches and Douglas-firs in alluvial stands rarely had more than three scars each, whereas ponderosa pines bordering pothole sites occasionally had 10 or more scars per tree. Also attesting to the more-severe fires that occurred in mixed conifer alluvial stands, most lack veterans older than 200 years. By contrast, ponderosa pines near potholes often range from 300 to 500 years old. However, fire severities on alluvial sites ranged from creeping underburns to partial- or total stand replacement on any given site. Consequently, such stands contain more species- and structural diversity than in the ponderosa pine type.

In terms of current successional trends, valley bottom alluvial sites apparently are more prone to unnatural succession due to fire exclusion than in stands near mountain canyons. In the valley bottom, site MFIs typically ranged from 30 to 50 years, and the long-term lack of fire has allowed shade

tolerant species an unprecedented period of development (fig. 9). By contrast, fire intervals and severities were more variable, but intervals were generally longer, on moist sites in and near mountain canyons. Therefore, stand succession in those areas apparently has been less affected by fire exclusion (fig. 10). Nonetheless, since most stands in the study area now have long fire intervals, an area-wide shift toward stand replacing fires has been occurring during the last 100 years in unlogged portions of the upper Swan Valley (Hart 1994).

Fig. 9. Successional Trends, WL-LP-DF
Alluvial Stand 7

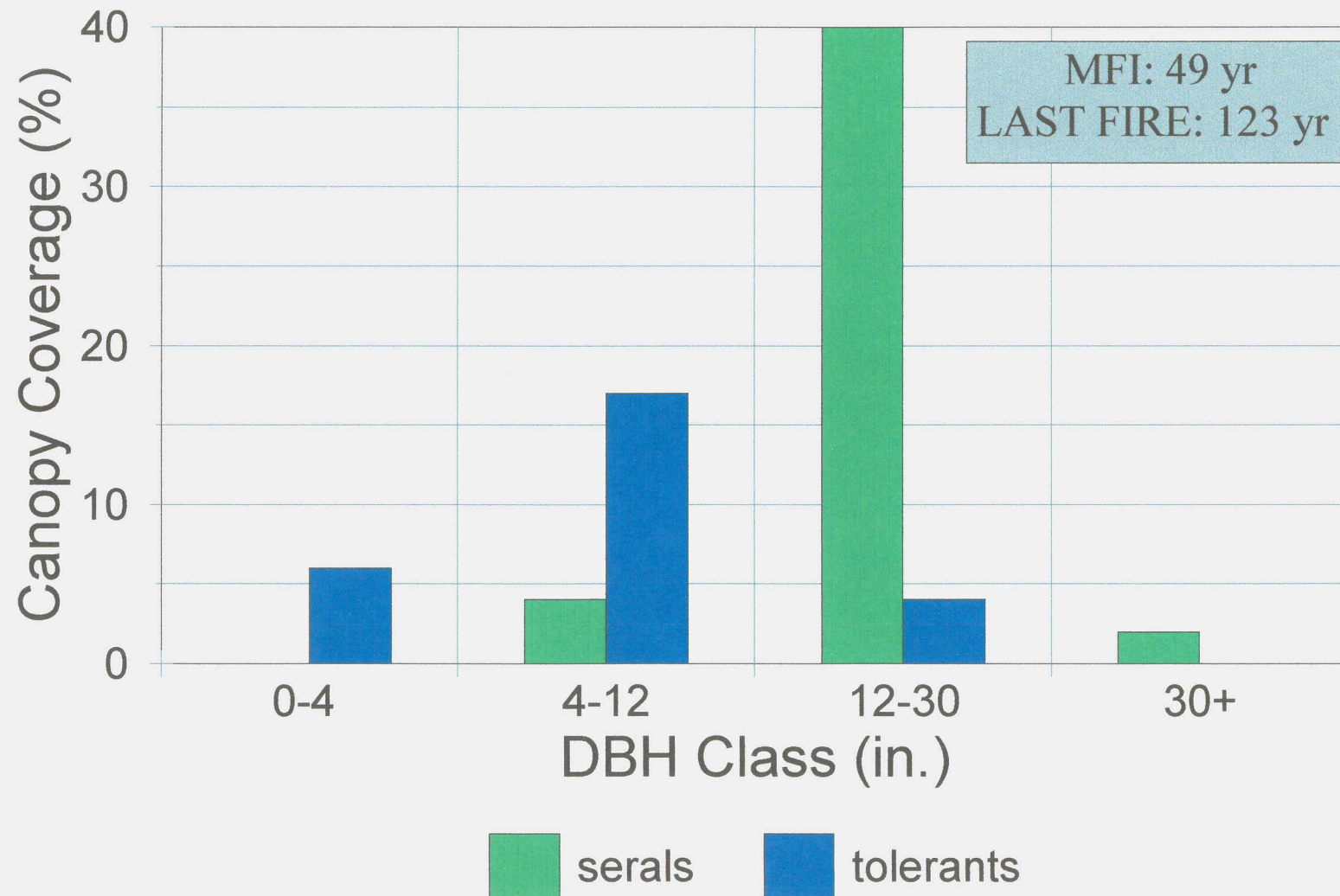
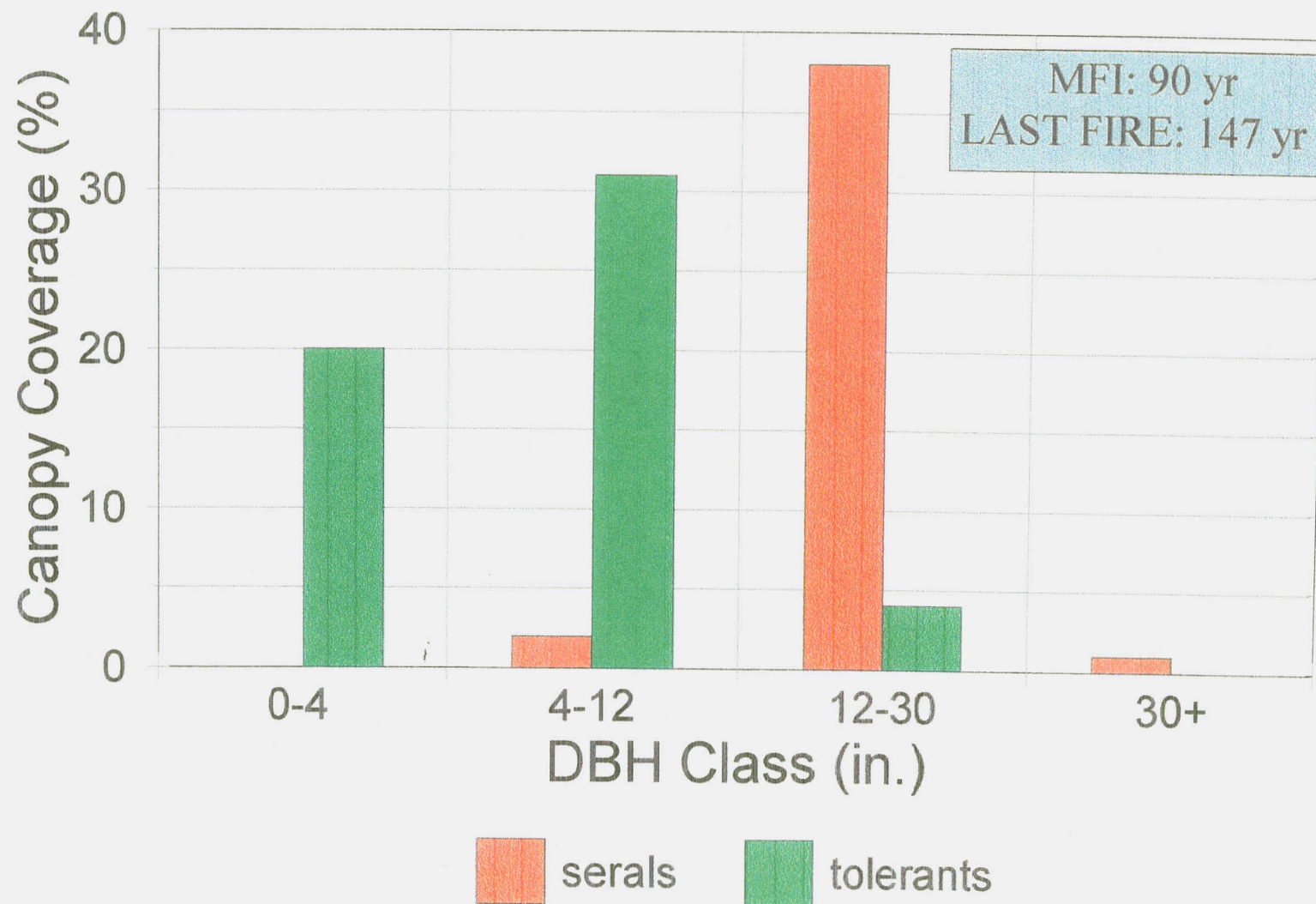


Fig.10 Successional Trends, WL-LP-WRC
Canyon-edge Alluvial Stand 1



SUMMARY

From at least 1600 to 1900, nonlethal and mixed severity fires were very frequent in relatively dry stands occupying the upper Swan Valley, including in riparian zones. Fires were frequently caused by lightning and Indians. However, long-term fire exclusion during the past 100 years has substantially disrupted area fire cycles, producing fundamental changes in the valley's lower elevation forests. At the stand scale, *species composition* has often shifted in pothole-edge stands that were previously dominated by ponderosa pine and western larch. Whereas the pre-1900 stands were dominated by early seral species, shade tolerant species now dominate the understories of many fire-excluded sites. *Stand structures* have also often changed since 1900. Tree densities in the ponderosa pine-larch dominated stands have shifted from relatively light- to moderately heavy stocking, greatly increasing the level of tree competition and ladder fuels. By contrast, the area's more productive alluvial stands have been less heavily impacted because fire intervals and severities were more variable. However, *area fire hazard* has been increasing across the valley landscape, posing a threat to the area's last old growth stands and threatening the nearby wildland/rural interface. Whether fire exclusion has benefitted or harmed water howellia habitat remains an open question—and likely could be addressed only through long-term observation of various management strategies.

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APPENDIX

Upper Swan Valley Master Fire Chronology (*Year: No. Plots*), including four fire years from Freedman and Habeck (1985) and Arno et al. (1997)(bold type=major fire years).

20 th Century	19 th Century	18 th Century	17 th Century	16 th /15 th Centuries
1919: 2	1899: 2	1798: 3	1688: 3	1578: 1
1905: 3	1889: 23	1788: 4	1677: 5	1489: 2
	1881: 1	1782: 4	1670: 13	
	1874: 2	1778: 1	1659: 5	
	1867: 10	1773: 1	1652: 2	
	1859: 7	1768 : 18	1634: 2	
	1853: 5	1757: 11	1625: 1	
	1850: 23	1751: 2	1609: 3	
	1839: 4	1744: 4	1600: 1	
	1835: 6	1735: 1		
	1825: 3	1721: 3		
	1822: 12	1716: 2		
	1817: 3	1710: 6		
	1814: 16	1700: 3		
	1806: 3			
	1802: 4			

Master Fire Chronology: 1600-1919

Number of Fires: 41

Fire Interval Range: 3-18 yr.

Mean Fire Interval: 8 yr.

Last Fire: 78 yr.